## ATTACHMENT 1

# The Pile Data Table

To ensure contract compliance, the designer must observe several standards when creating the Pile Data Table:

1. If the ENR formula is to be used for pile acceptance criteria, the Design Loading must be shown.
2. The Nominal Resistance* must be shown for *all* piles, regardless of pile type or acceptance criteria. The Standard Specifications allow the Contractor to revise specified tip elevations as long as the required Nominal Resistance is provided and verified through a static load test. The Nominal Resistance is also needed for acceptance by Wave Equation Analysis.
3. The Design Loading shall be rounded up to the nearest 25 kN.
4. The Nominal Resistance shall be rounded up to the nearest 50 kN.
5. When using WSD, the Nominal Resistance is equal to two (2) times the rounded up Design Loading.
6. When ENR is used as the acceptance criteria for LFD, the Design Loading is equal to one half (1/2) the rounded up Nominal Resistance.
7. The Cutoff Elevation is required in the Pile Data Table whenever it cannot be calculated from the bottom of footing elevation and pile head embedment shown on the plans. Pier columns and pile shaft extensions, which have no footings, require a Cutoff Elevation in the Pile Data Table.
8. The Design Tip Elevations for compression, tension, lateral, scour, liquefaction, or a combination of these loads are required on the plans. These elevations express the “intent” of the design and help the field engineer to resolve constructibility and quality issues.
9. The Specified Tip Elevation is the controlling (deepest) value of the Design Tips.
10. When the Specified Tip Elevation is controlled by lateral load, scour, or liquefaction, the Specified Tip Elevation shall not be raised. The static load test to verify nominal resistance cannot duplicate these conditions.

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*The Nominal Resistance is the analytically estimated load carrying capacity of a foundation calculated using nominal dimensions and material properties, and established soil mechanics principles. Loads as high as the Nominal Resistance are on the verge of failing the soil, but not necessarily the structural member.

# ATTACHMENT 1

When requesting specified pile tip elevations, the bridge designer will provide the geotechnical engineer with the following:

- For foundations designed by WSD, provide the Design Loading.
- For foundations designed by LFD, provide the required Nominal Resistance (tension and compression).

The following examples show the required formats for presenting **PILE DATA** on the contract plans. Highlighted in bold font is the information the bridge designer provides to the geotechnical design engineer to determine specified pile tip elevations. In each case the pile loads were determined at the abutments by using WSD and at the bents by using LFD.

- Example #1 – Standard Plan Piles
- Example #2 – Steel HP Piles and CIDH Piles w/ Permanent Steel Casing
- Example #3 – Steel Pipe Piles, Large CISS Piles and Pier Columns
- Example #4 – Large CIDH Piles and Steel Pipe Piles
- Example #5 – Large CIDH Piles w/ Driven Steel Shells

## ATTACHMENT 1

# Example #1 Standard Plan Piles

A three span overcrossing with single column bents and seat abutments uses Standard Plan piles. Shown in the Table 1 are the actual load demands on the piles based upon WSD and LFD. Standard Plan Class 625 piles will be utilized at the abutments and Class 900 piles at Bent 2 and 400-mm CIDH at Bent 3. Standard Specification 49-1.08 (ENR) will be used as the pile acceptance criteria.

**Table 1**

| Location | WSD Design Loading | | LFD Factored Load (Controlling Load Group) | |
|---|---|---|---|---|
| | Compression | Tension | Compression | Tension |
| Abut 1 | 583 kN | 0 kN | --- | --- |
| Bent 2 | --- | --- | 1621 kN (VII) | 730 kN (VII) |
| Bent 3 | | | 1604 kN (VII) | 739 kN (VII) |
| Abut 4 | 567 kN | 0 kN | --- | --- |

Table 2 shows the foundation information that the structure designer puts on the contract plans. Shown in **bold font** are the values that the structure designer will provide to the geotechnical design engineer to determine the specified pile tip elevations. Note that when seismic loads (Group VII) control the factored load, the strength reduction factor is $\phi = 1.0$, so that the nominal resistance equals the pile's factored load demand. Strength reduction factors are not applied in WSD, so there is no adjustment based on load group. As with many foundations using large pile groups in competent soil, the lateral load on each pile is low and the associated design tip elevation was not calculated.

**Table 2**

PILE DATA TABLE

| Location | Pile Type | Design Loading | Nominal Resistance | | Design Tip Elevations | Specified Tip Elevations |
|---|---|---|---|---|---|---|
| | | | Compression | Tension | | |
| Abutment 1 | Class 625 | 600 kN | 1200 kN | 0 kN | 47.0(1) | 47.0 |
| Bent 2 | Class 900 | 825 kN | 1650 kN | 750 kN | 45.0(1); 55.0(2) | 45.0 |
| Bent 3 | 400mm CIDH (900 kN) | N/A | 1650 kN | 750 kN | 45.0(2); 50.0(1) | 45.0 |
| Abutment 4 | Class 625 | 575 kN | 1150 kN | 0 kN | 48.0(1) | 48.0 |

Design tip elevation is controlled by the following demands:
(1) Compression, (2) Tension

## ATTACHMENT 1

# Example #2 Steel HP Piles and CIDH Piles with Permanent Steel Casing

The following example is for a typical undercrossing with multi-column bents (pinned footings) and seat abutments. Driven non-displacement steel piles will be utilized at the abutments and CIDH piles with permanent steel casing at the bent due to utility conflicts and vibration concerns. The permanent steel casing is for water control only and is not designed to develop any geotechnical resistance. Shown in Table 3 are the actual load demands on the piles based upon WSD and LFD. Standard Specification 49-1.08 (ENR) will be used as the pile acceptance criteria at Abutments 1 and 3.

**Table 3**

| Location | WSD Design Loading | | LFD Factored Load (Controlling Load Group) | |
|---|---|---|---|---|
| | Compression | Tension | Compression | Tension |
| Abut 1 | 610 kN | 0 kN | --- | --- |
| Bent 2 | --- | --- | 1403 kN (I) | 23 kN (IV) |
| Abut 3 | 621 kN | 0 kN | --- | --- |

Table 4 shows the foundation information that the structure designer puts on the contract plans. Shown in **bold font** are the values that the structure designer will provide to the geotechnical design engineer to determine the specified pile tip elevations. Note that non-seismic loads control at Bent 2, so the controlling factored load is divided by $\phi = 0.75$ to get the nominal resistance. Also note that since ENR is not used for a drilled pile, no Design Loading is shown at Bent 2.

**Table 4**

PILE DATA TABLE

| Location | Pile Type | Design Loading | Nominal Resistance | | Steel Casing Specified Tip Elevation | Design Tip Elevations | Specified Tip Elevations |
|---|---|---|---|---|---|---|---|
| | | | Compression | Tension | | | |
| Abutment 1 | HP250X85 | 625 kN | 1250 kN | 0 kN | N/A | 32.0(1) | 32.0 |
| Bent 2 | 1.2m CIDH w/permanent steel casing | N/A | 1900 kN | 50 kN | 40.0 | 25.0(1); 35.0(2) | 25.0 |
| Abutment 3 | HP 250X85 | 625 kN | 1250 kN | 0 kN | N/A | 32.0(1) | 32.0 |

Design tip elevation is controlled by the following demands:
(1) Compression, (2) Tension

# ATTACHMENT 1

## Example # 3 Steel Pipe Piles, Large CISS Piles and Pier Columns

The following example is for a multi-span river crossing. Steel pipe piles will be utilized at the abutments, CISS piles at the river piers, and pier columns at piers away from the river. Standard Specification 49-1.08 (ENR) will be used as the pile acceptance criteria at Abutments 1 and 6. At Piers 2 and 3, "Wave Analysis" will be used for pile acceptance. Shown in Table 5 are the actual load demands on the piles based upon WSD and LFD.

**Table 5**

| Location | WSD Design Loading | | LFD Factored Load (Controlling Load Group) | |
|---|---|---|---|---|
| | Compression | Tension | Compression | Tension |
| Abut 1 | 841 kN | 0 kN | --- | --- |
| Pier 2 | --- | --- | 4117 kN (VI) | 1783 kN (VII) |
| Pier 3 | --- | --- | 3797 kN (VI) | 1677 kN (VII) |
| Pier 4 | --- | --- | 17967 kN (VI) | 0 kN |
| Pier 5 | --- | --- | 15728 kN (VI) | 0 kN |
| Abut 6 | 829 kN | 0 kN | --- | --- |

Table 6 shows the foundation information that the structure designer puts on the contract plans. Shown in **bold font** are the values that the structure designer will provide to the geotechnical design engineer to determine the specified pile tip elevations. The design tip elevations controlled by lateral loads (3) are calculated by the structure designer. Note (5) is appropriate at Pier 2 because scour controls the design, and at Pier 3 because lateral load controls. Note (5) is not applied at Piers 4 and 5 because tip revisions are not normally allowed for drilled piles.

**Table 6**

PILE DATA TABLE

| Location | Pile Type | Design Loading | Nominal Resistance | | Cut-Off Elevation | Design Tip Elevations | Specified Tip Elevations |
|---|---|---|---|---|---|---|---|
| | | | Compression | Tension | | | |
| Abut 1 | PP 406X12.70 | 850 kN | 1700 kN | 0 kN | N/A | -3.0(1) | -3.0 |
| Pier 2 | CISS PP1067X15.88 | N/A | 5500 kN | 1800 kN | N/A | -22.0(1,4); -10.0(2,4); -18.0(3,4) | -22.0(5) |
| Pier 3 | CISS PP1067X15.88 | N/A | 5100 kN | 1700 kN | N/A | -20.0(1); -12.0(2); -21.0(3) | -21.0(5) |
| Pier 4 | 3.0m Pier Column | N/A | 24000 kN | 0 kN | 10.0 | -15.0(1); -12.0(3) | -15.0 |
| Pier 5 | 3.0m Pier Column | N/A | 21000 kN | 0 kN | 15.0 | -9.0(1); -10.0(3) | -10.0 |
| Abut 6 | PP 406X12.70 | 850 kN | 1700 kN | 0 kN | N/A | -3.0(1) | -3.0 |

Design tip elevation is controlled by the following demands:
(1) Compression; (2) Tension; (3) Lateral Loads; (4) Scour Potential exist to Elev 5.0 @ Pier 2;
(5) Specified Tip Elevation shall not be raised.

## ATTACHMENT 1

# Example # 4 Large CIDH Piles and Steel Pipe Piles

The following example is for a seismic retrofit of a three span overcrossing. Large CIDH piles will be utilized at both abutments for lateral restraint. Driven steel pipe piles will be used at Bent 2 due to the presence of high ground water. Due to existing structures near Bent 3, CIDH piles will be used to minimize ground disturbance. During the field study ground water was encountered near Bent 3, so 600mm CIDH piles will be used. Standard Specification 49-1.08 (ENR) will be used as the pile acceptance criteria at Bent 2. Shown in Table 7 are the actual load demands on the piles based upon LFD.

**Table 7**

| Location | WSD Design Loading | | LFD Factored Load and (Controlling Load Group) | |
|---|---|---|---|---|
| | Compression | Tension | Compression | Tension |
| Abut 1 | --- | --- | --- | --- |
| Bent 2 | --- | --- | 720 kN (V) | 305 kN (V) |
| | | | 880 kN (VII) | 445 kN (VII) |
| Bent 3 | --- | --- | 1291 kN (VII) | 1270 kN (VII) |
| Abut 4 | --- | --- | --- | --- |

Table 8 shows the foundation information that the structure designer puts on the contract plans. Shown in **bold font** are the values that the structure designer will provide to the geotechnical design engineer to determine the specified pile tip elevations.

At Bent 2, the nominal resistance in compression is controlled by Group V, even though the Group VII factored load is larger. The strength reduction factor makes the difference: 720/0.75=960 kN is greater than 880/1.0=880 kN; round 960 kN up to 1000 kN for the table. In tension, the seismic load combination controls nominal resistance.

The Cut-Off Elevation is shown at the abutments because the CIDH piles in this design extend all the way up to the superstructure, and there is no bottom of footing elevation to define the cut-off.

**Table 8**

PILE DATA TABLE

| Location | Pile Type | Design Loading | Nominal Resistance | | Cut-Off Elevation | Design Tip Elevations | Specified Tip Elevations |
|---|---|---|---|---|---|---|---|
| | | | Compression | Tension | | | |
| **Abut 1** | **1.8m CIDH** | **N/A** | **0 kN** | **0 kN** | **65.0** | **50.0(3)** | **50.0** |
| **Bent 2** | **PP406X12.70** | **500 kN** | **1000 kN** | **450 kN** | **N/A** | **45.0(1,4); 41.0(2,4)** | **41.0(5)** |
| **Bent 3** | **600mm CIDH** | **N/A** | **1300 kN** | **1300 kN** | **N/A** | **42.0(1,4); 38.0(2,4)** | **38.0** |
| **Abut 4** | **1.8m CIDH** | **N/A** | **0 kN** | **0 kN** | **60.0** | **44.0(3)** | **44.0** |

Design tip elevations are controlled by the following demands:
(1) Compression; (2) Tension; (3) Lateral Loads; (4) Liquefaction potential exists from Elev. 50 to 55. (5) Specified Tip Elevation shall not be raised.

# Example # 5 Large CIDH Piles with Driven Steel Shell

The following example is that of the seismic retrofit of a major river crossing where large CIDH piles are recommended with permanent, driven steel shells. The shell is required to facilitate construction and will be required to develop a portion of the required nominal resistance. The shell is to be installed by driven methods only and "Wave Analysis" will be used for pile acceptance. Shown in the Table 9 are the actual load demands on the piles based upon LFD.

**Table 9**

| Location | LFD Factored Load (Controlling Load Group) | |
|---|---|---|
| | Compression | Tension |
| Pier 5 | 4961 kN (VII) | 2193 kN (VII) |

Shown in Table 10 is the foundation information that the structure designer shows on the contract plans. Shown in **bold font** are the values that the structure designer will provide to the geotechnical design engineer to determine the specified pile tip elevations. The geotechnical design engineer will furnish the Nominal Resistance for the driven shell.

**Table 10**

PILE DATA TABLE

| Location | Pile Type | Design Loading | Nominal Resistance | | Nominal Resistance (Driven Steel Shell) | | Specified Tip Elevation (Shell) | Design Tip Elevations | Specified Tip Elevations (CIDH) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Compression | Tension | Compression | Tension | | | |
| Pier 5 | 1.6m CIDH w/PP1800X19.05 Driven Steel Shell | N/A | 5000 kN | 2200 kN | 2600 kN | 1100 kN | -50.0 | -55.0(1)<br>-65.0(2) | -65.0 |

Design tip elevations are controlled by the following demands:
(1) Compression; (2) Tension